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Orbital Mission Analysis Branch

MISSION PLANNING AND ANALYSIS DIVISION

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PROJECT APOLLO

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By Jerome W. Kahanek
Orbital Mission Analysis Branch

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CHANGES TO THE DKI LOGIC

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By Jerome W. Kahanek

SUMMARY AND INTRODUCTION

The purpose of this internal note is to describe changes desired by the Orbital Mission Analysis Branch to the RTCC DKI processor (ref. 1) for Apollo Mission G and any subsequent missions. The changes desired are as follows.

1. Ability to input the position of terminal phase initiation (TPI), either as a particular time or as a lighting condition, instead of being able to specify only the rendezvous point (TPF) based on lighting conditions, longitude crossing, or angle around the sun.

2. A change to the method used to compute the phase angle necessary at TPI to satisfy the input elevation angle (ref. 2)

3. A change to the method used in subroutine FIND to compute TPI time from the TPF time (ref. 3).

DISCUSSION OF THE CHANGES

The first change would comprise a flag setting which would indicate that TPI position is being input. Now, the RTCC program finds the time of rendezvous (TPF), and then to find the TPI time substracts the time required for the target vehicle to travel through the transfer angle ωt. If TPI position were input as a time, the call to subroutine FIND to obtain TPF time could be bypassed because TPI would already be known. If TPI position were input as a lighting condition, subroutine FIND would have to be flagged to keep the time it finds as the TPI time instead of TPF time.

The reason for this change is that the mission planners' philosophy has changed from specification of the rendezvous point to specification of the TPI position, usually relative to a certain lighting condition.

Change 2 is necessary to compute an accurate TPI phase angle if the orbits prior to TPI are elliptic. It was found that use of the old method for computation of the phase angle at TPI could result in a 2- to 3-minute error in the time of TPI if the orbits were elliptic, such as encountered in Apollo 11 abort and rescue situations.

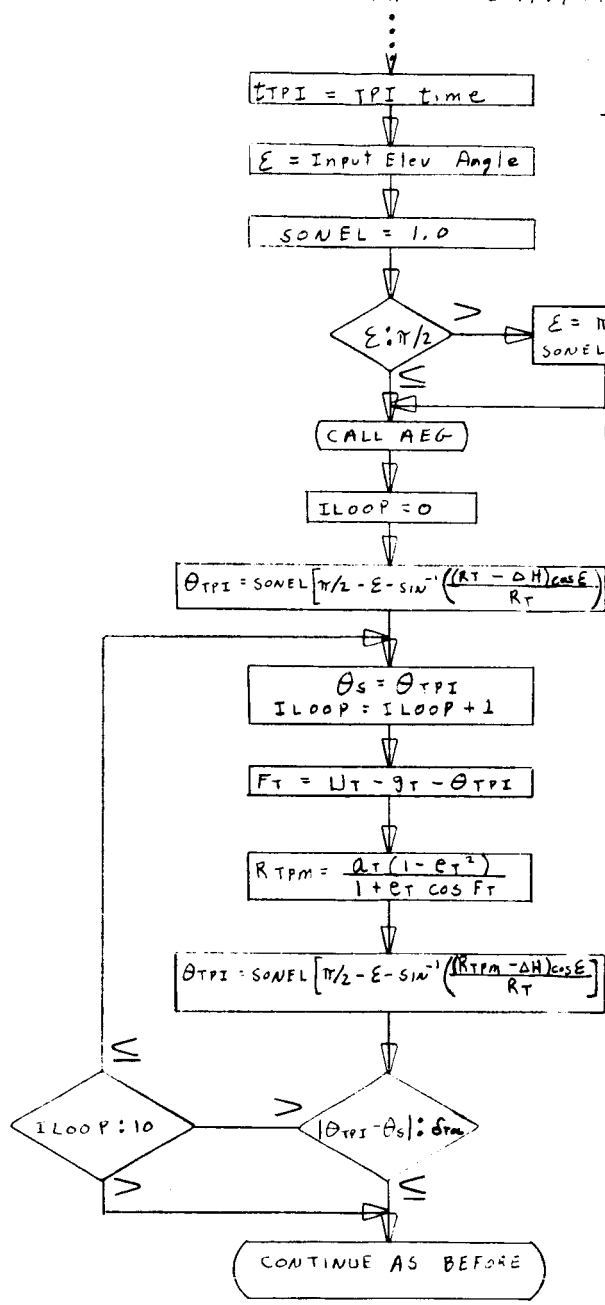
This error was caused by use of the wrong target radius for computation of the chaser radius which is used in the phase angle equation. In circular orbits, the target radius does not change appreciably over the phase angle arc at TPI; therefore, the error was never evident in past circular orbit rendezvous.

The new method computes a phase angle at TPI by an update of the target vehicle to the time of TPI and by use of the target radius and input delta height at this point to compute a chaser radius to be used for computation of a first guess phase angle. By use of this phase angle, the true anomaly of the target vehicle at TPI phase match (the position at which the target lies on the same radius vector as the chaser) is computed, and this true anomaly is used to compute the target radius at TPI phase match. Then new chaser radius at TPI is computed from the target radius at TPI phase match and from the input delta height. This chaser radius is then used to recompute the phase angle desired at TPI. This sequence of computations is continued until two successive phase angles are within 0.01° tolerance. This iteration is shown in flow chart 1.

Change 3 is desired so that if TPF time is specified in the DKI than the TPI time computed relative to the TPF time will be computed similarly to the way the two-impulse processor computes TPF time relative to TPI time. The change is to compute the TPI time as the time of arrival at some argument of latitude instead of the time required for the chaser vehicle to travel through the transfer angle.

The argument of latitude of TPI is found by updating the target vehicle to TPF time and then subtracting the transfer angle ωt from the argument of latitude at TPF. The chaser vehicle is moved until its argument of latitude is within 0.01° tolerance of the TPI argument of latitude. When this tolerance is passed, the time of TPI is defined and the computation of the phase angle at TPI is computed as previously discussed.

Logic Showing the Computation of Phase Angle Desired at Terminal Phase Initiation (TPI)



Either input or gotten from Subroutine FIND

UPDATE TARGET VECTOR TO t_{TPI}

COMPUTE FIRST GUESS PHASE ANGLE USING TARGET RADIUS AT TPI

SAVE PHASE DESIRED AT TPI

TRUE ANOMALY OF TARGET AT TPI PHASE MATCH

RADIUS OF TARGET AT TPI PHASE MATCH

RECOMPUTE PHASE ANGLE DESIRED AT TPI USING TARGET RADIUS AT TPI PHASE MATCH

CHECK PHASE ANGLE AT TPI AGAINST PREVIOUS VALUE

COMPUTE PHASE ANGLE DESIRED AT NSR.

REFERENCES

1. Regelbrugge, R. R.: Logic for Real Time Computation of the Docking Initiation Table Display, MSC Internal Note No. 64-FM-59, Nov. 25, 1964.

2. McHenry, E. N.: Logic for Real-Time Computation of the Desired Phase Lag at the Comparison Point Based on the Sunlighting Constraint or a Chosen Rendezvous Position, MSC Internal Note No. 64-FM-89, Dec. 9, 1964.

3. McHenry, E. N.: Logic and Equations for Real-Time Computation of Station Contracts, Ordering an Array of Contracts, and Establishing the Position and Time of Rendezvous, MSC Internal Note No. 64-FM-48, Nov. 20,1964.